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Does organic farming benefit farmland birds in winter?

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The generally higher biodiversity on organic farms may be influenced by management features such as no synthetic pesticide and fertilizer inputs and/or by differences in uncropped habitat at the site and landscape scale. We analysed bird and habitat data collected on 48 paired organic and conventional farms over two winters to determine the extent to which broad-scale habitat differences between systems could explain overall differences in farmland bird abundance. Density was significantly higher on organic farms for six out of 16 species, and none on conventional. Total abundance of all species combined was higher on organic farms in both years. Analyses using an information-theoretic approach suggested that both habitat extent and farm type were important predictors only for starling and greenfinch. Organic farming as currently practised may not provide significant benefits to those bird species that are limited by winter food resources, in particular, several declining granivores.

Keywords: agri-environment schemes; farming systems; Farmland Bird Indicator

1. INTRODUCTION

Abundant evidence exists to show that recent large-scale declines in farmland biodiversity in Europe are linked to profound changes in agricultural management (e.g. Donald *et al.* 2001). Organic farming provides a less-intensive approach to food production. Biodiversity on organic farms tends to be greater (Bengtsson *et al.* 2005; Fuller *et al.* 2005; Hole *et al.* 2005), hence organic farming has been proposed as a potential tool by which biodiversity declines may be reversed. It is evident from a number of studies that organic farms tend to have greater farm-level habitat heterogeneity owing to broad differences in cropping patterns and better/more extensive non-crop habitats at the site and landscape levels (e.g. Rundlof & Schmidt 2006; Norton *et al.* 2009). It therefore remains unclear whether organic farms support greater biodiversity owing to management of inputs to the system (e.g. no synthetic pesticides or fertilizers), to heterogeneity in wider habitat composition (Chamberlain *et al.* 1999; Gibson *et al.* 2007) or both.

We compare winter bird abundance and species richness between farm types (FTYP) (organic or conventional) for a group of Farmland Bird Indicator (FBI) species. Trend in a combined FBI index has been adopted by the UK government as an indicator of the health of the wider farmland environment and is a key driver of agri-environmental policy (Gregory *et al.* 2004). We use an information-theoretic approach (Burnham & Anderson 2002) to consider the relative importance of FTYP, compared with variables describing habitat extent, in predicting bird numbers and species richness for FBI species.

Electronic supplementary material is available at http://dx.doi.org/10.1098/rsbl.2009.0643 or via http://rsbl.royalsocietypublishing.org.

2. MATERIAL AND METHODS

Organic sites were selected from a certified list and paired with a conventional farm on the basis of proximity and crop type, and identical bird surveys were carried out on both (details in electronic supplementary material). During each survey visit, the observer walked the perimeter and once across the centre of each field. The locations of all birds seen or heard were recorded when first detected. Surveys were undertaken once per month to each site between October and February inclusive and were carried out over two winters (2000/2001 and 2002/2003, referred to as 2001 and 2003, respectively). Forty-three farm pairs were surveyed in 2001 and 34 pairs in 2003. Habitat attributes of the fields (e.g. crop or other field type) and non-crop habitats (hedgerows, presence and extent of field margins, small woods) were recorded.

The analysis focused on 16 FBI species (table 1). Total abundance (A_{FBI}) and species richness (S_{FBI}) of FBI species were also determined per site. The latter was estimated from rarefaction curves (Magurran 2004) standardized to 20 individuals. Bird count per visit (for individual species and A_{FBI}) was analysed using a generalized linear model with log(survey area) included as an offset, in relation to FTYP (i.e. organic or conventional) and farm pair (thus maintaining the paired structure). Negative binomial errors were specified, which provided better fitting models than Poisson errors (most species considered show high variability in counts owing to the occurrence of sometimes large flocks). If a given species was not recorded on either site in a pair, then that pair was omitted from the analysis (hence sample sizes differ between species). In order to account for multiple visits to each site, a repeated-measures model structure was specified. Species richness was analysed using a normal errors model, including farm pair and FTYP as above. Initial analyses considered the effect of FTYP only in order to determine overall differences in density/richness between farm systems.

A second set of analyses using the same model structures was undertaken, which included additional habitat variables identified from previous studies as being possible determinants of winter bird density. For each species, a literature search was undertaken to identify potential predictors of winter bird abundance and therefore to construct candidate models (table S1 in electronic supplementary material). Seven variables were at the site level: habitat diversity (calculated with the Shannon formula), hedgerow density (km ha^{-1}), arable area (except stubbles), grass area, stubble area, field margin area and woodland area. A further three variables were extracted from Land Cover Map 2000 data (Fuller *et al.* 2002) at a 3×3 km scale, where the survey site occupied the central square: woodland area, arable–grass ratio and this ratio squared.

For species showing FTYP effects, an information-theoretic approach was used (Burnham & Anderson 2002). We determined the average parameter estimate for FTYP over all candidate models, weighted by Akaike information criteria (AIC$_c$), and calculated the Akaike weight, ω_i, for FTYP across all candidate models (model-averaged parameter estimates, and ω_i for other predictor variables are given in tables S2 and S3 in electronic supplementary material).

3. RESULTS

Density was significantly higher on organic farms for stock dove *Columba oenas*, starling *Sturnus vulgaris*, jackdaw *Corvus monedula* and linnet *Carduelis cannabina* in 2001, and for woodpigeon *Columba palumbus* and greenfinch *Carduelis chloris* in 2003. A_{FBI} was significantly higher on organic farms in both years

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Table 1. Mean ± s.e. difference (organic–conventional) in species abundance (individuals per hectare for separate species), combined species abundance (A_{FBI}, individuals per hectare for combined FBI species) and species richness standardized to 20 individuals (S_{FBI}) on organic and conventional farms, derived from least-squares means. (n = number of sites. n.a. = model did not converge on a solution. Scientific names of species are given in the electronic supplementary material.)

species	mean difference	n	p
2001			
kestrel	0.021 ± 0.295	64	n.a.
grey partridge	0.305 ± 0.454	30	0.780
lapwing	−3.083 ± 0.546	28	0.054
woodpigeon	0.459 ± 0.195	86	0.140
stock dove	1.761 ± 0.356	52	0.015
skylark	−0.142 ± 0.253	78	0.745
starling	1.853 ± 0.298	68	0.017
rook	0.780 ± 0.266	72	0.191
jackdaw	1.766 ± 0.234	80	0.007
tree sparrow	0.434 ± 0.624	14	0.730
greenfinch	0.936 ± 0.306	74	0.064
goldfinch	0.372 ± 0.270	74	0.401
linnet	2.033 ± 0.376	40	0.027
yellowhammer	0.067 ± 0.238	80	0.854
reed bunting	1.276 ± 0.562	22	0.188
corn bunting	−3.463 ± 0.818	8	0.211
A_{FBI}	0.489 ± 0.143	86	0.012
S_{FBI}	0.457 ± 0.254	80	0.080
2003			
kestrel	0.029 ± 0.264	62	0.915
grey partridge	−0.270 ± 0.367	40	0.683
lapwing	−1.031 ± 0.451	36	0.679
woodpigeon	0.568 ± 0.194	68	0.046
stock dove	0.789 ± 0.352	48	0.281
skylark	−0.061 ± 0.217	66	0.845
starling	0.476 ± 0.264	62	0.400
rook	0.798 ± 0.285	58	0.171
jackdaw	1.467 ± 0.318	58	0.084
tree sparrow	1.551 ± 0.701	16	0.203
greenfinch	0.859 ± 0.276	64	0.044
goldfinch	0.815 ± 0.326	56	0.182
linnet	0.902 ± 0.367	54	0.694
yellowhammer	−0.419 ± 0.241	62	0.272
reed bunting	0.574 ± 0.462	38	0.472
corn bunting	−1.233 ± 0.795	8	0.575
A_{FBI}	0.428 ± 0.152	68	0.035
S_{FBI}	0.161 ± 0.246	66	0.517

(table 1). For those species that showed an effect of FTYP that was significant, or that approached significance ($p < 0.10$), model-averaged parameter estimates and model weights are given in table 2. This revealed strong support of an effect of FTYP, in terms of a high ω_i and confidence intervals not overlapping zero, only for starling and greenfinch (table 2).

4. DISCUSSION

A minority of FBI species had (mostly weakly) significantly higher densities on organic farms, although the majority of species' densities were greater on organic farms and there was significantly greater total density on organic farms. Only lapwing *Vanellus vanellus* (in 2001) showed a (non-significant) trend towards higher density on conventional farms. The information-theoretic approach suggested that both habitat extent and FTYP were important predictors for starling and greenfinch, but otherwise there was no evidence that FTYP was an important predictor when accounting for other habitat variables.

Table 2. Model-averaged parameter estimates and 95% confidence limits for the effects of FTYP for species/groups showing a tendency for farm-type differences. (Positive parameter estimates indicate greater density/species richness on organic farms than on conventional farms. ω_i is the summed model weight for FTYP.)

species	FTYP	ω_i
2001		
lapwing	−0.373 (−0.584, 5.101)	0.126
stock dove	0.302 (−3.082, 3.686)	0.162
starling	2.878 (1.565, 4.189)	0.966
jackdaw	0.659 (−1.267, 2.585)	0.420
greenfinch	0.111 (−1.411, 1.633)	0.145
linnet	1.207 (−0.657, 3.070)	0.595
A_{FBI}	0.169 (−0.542, 0.881)	0.353
S_{FBI}	0.001 (−1.028, 1.028)	0.001
2003		
woodpigeon	0.015 (−0.553, 0.583)	0.065
jackdaw	0.181 (−1.590, 1.953)	0.182
greenfinch	1.693 (1.037, 2.350)	0.999
A_{FBI}	0.052 (−0.610, 0.713)	0.160

Habitat structure is a principal correlate of spatial variation in bird abundance on farmland (Fuller *et al.* 1997). Norton *et al.* (2009) found a greater extent of non-crop habitats and more heterogeneous land use in a sample of organic farms in the UK (of which this study is a subset). Variation in structural habitat is likely to be a key factor in explaining the organic–conventional contrast in birds. For example, variables that are known to systematically vary between farming systems (Norton *et al.* 2009) and which were strongly linked to winter bird density included hedgerow density (A_{FBI}), proportion of arable area at the farm scale (stock dove, jackdaw) and grass : arable ratio at the landscape scale (woodpigeon, jackdaw), although there were some models where no consistent effects of any variable were found (table S2 in electronic supplementary material). Similar effects of cropping patterns and landscape complexity, coupled with relatively weak effects of organic management, have been found for breeding birds (Piha *et al.* 2007; Kragten & de Snoo 2008). Furthermore, landscape structural heterogeneity is a key component of overall system differences for invertebrates (Schmidt *et al.* 2005; Rundlof & Schmidt 2006). Similarly, the results presented here suggest that the 'physical' habitat of farmland is likely to explain much variation in winter bird abundance between systems.

Availability of food resources in winter is likely to be a key limiting factor for many FBI species, especially granivorous passerines, and their decline is strongly linked to loss of key foraging habitats such as stubbles (e.g. Gillings *et al.* 2005). Our observations suggest that this group of species may not benefit (in winter) from wider adoption of organic farming practices. The general lack of farm-type differences could be strongly influenced by stubble availability. Although higher arable weed abundance on organic farms (Fuller *et al.* 2005) may be expected to increase winter food resources, at the time of the study stubbles were more prevalent on conventional farms (Norton *et al.* 2009), as organic farmers cannot afford the resulting weed burden. The majority of species identified in this paper likely to most benefit from organic farming practices in winter were increasing species and as such are not of conservation priority. Starling was the only decreasing species (Gregory *et al.* 2004) to show strong effects of FTYP when accounting for broad-scale habitat variation, possibly owing to better foraging provided by organic grass management (temporary grass leys and application of farmyard manure).

We conclude that variation in broad-habitat extent is a better predictor of bird abundance and richness than FTYP *per se*. As well as lack of pesticide and synthetic fertilizer use, organic farms differ from conventional farms in terms of a range of habitat variables and management practices (Norton *et al.* 2009), which vary in the extent to which they could be considered intrinsic to the system. Organic farming has clear benefits for a range of taxa (e.g. Hole *et al.* 2005), but some aspects of organic farming may not currently provide significant benefits to bird species that are limited by winter seed resources. However, a reduction in stubbles on non-organic farmland, as has recently occurred with the phasing-out of set-aside, could result in organic farms becoming more heavily used by some granivorous species.

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